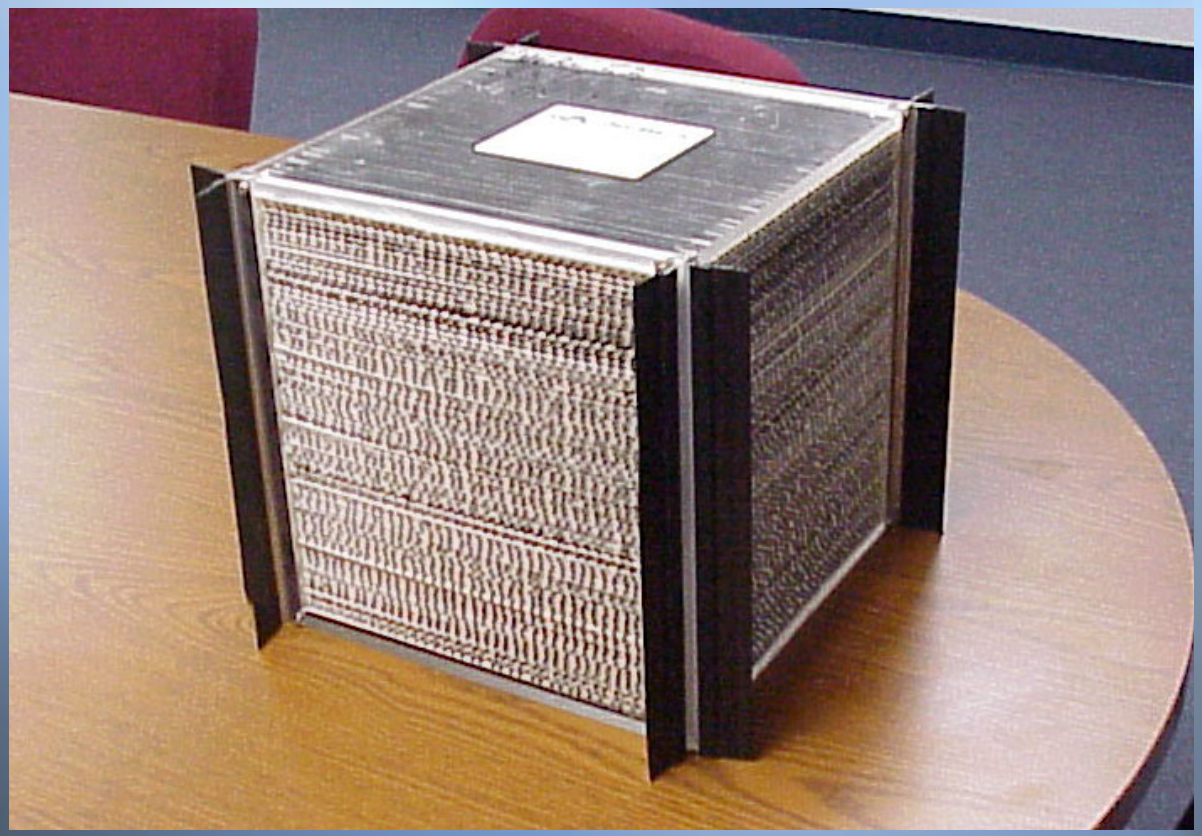
HIGH PERFORMANCE
LOW COST
DESICCANT COMPONENT
TECHNOLOGY DEVELOPMENT

Dais Analytic Corporation

DESICCANT COMPONENT
Membrane Energy Recovery Ventilator: MERV
a solid state sensible and latent heat exchanger



DISTRIBUTED ENERGY RESOURCES

NREL

Desiccant Technology Development

- Presentation Structure
  - Dais Analytic Background
  - Membrane materials
  - Membrane structures
  - Applications
  - Remaining Challenges
  - Summary

Dais Analytic Background

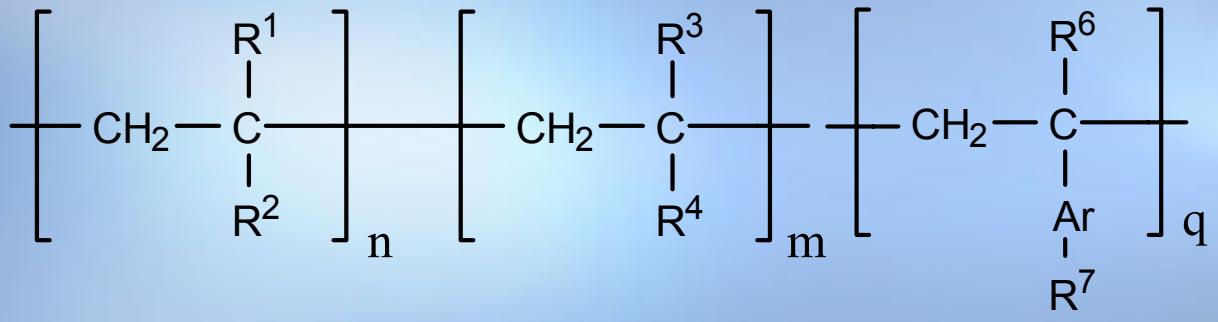
- An energy technology company”
  - Formed in 1993
  - HQ in Odessa, FL, Private, 28 employees, growing
  - Experienced Management Team
  - 3 PhD's, 10 Degreed Engineers
  - Academic & National Lab Involvement
  - Focused on Advanced Polymer materials
  - Products: moisture membranes, ERV, fuel cells

Dais Analytic Moisture Membrane

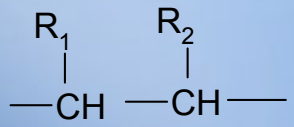
- Intellectual Property
  - 6 Patents Issued – Hydrocarbon Materials
    - Ion Conducting Membranes (2)
    - Moisture Transfer Membranes
    - Desalination Membranes
    - Fuel Cell Catalytic Structures for Hydrocarbon Membranes
  - 7 other patents pending
    - Membrane Structures
    - Membrane Synthesis / Chemistry (2)
    - Ventilator Assembly Structures
    - Fuel Cell Bi-Polar Plates
    - Fuel Cell Stack Sensors/Operation
    - Fuel Cell Electrodes

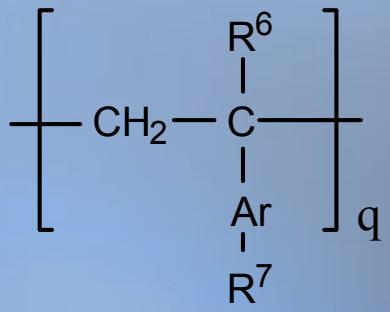
Moisture Membrane Materials

- **All membranes are hydrocarbon variants**
  - **Blocked Structures (Tri or Multi-Block)**



  - **Random Block or Random Monomer Arrangements**



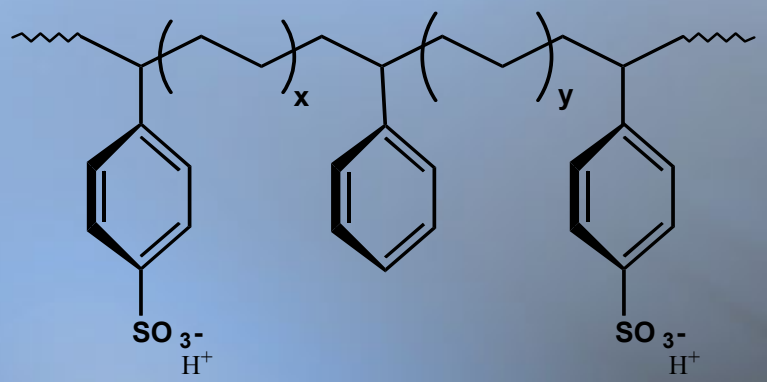


R_z = H, CH_3, CH_2CH_3, C_nH_{2n+1}

z = 1, 2; n = 1, 2, 3,....

Moisture Membrane Material

- Material Process starting with the base resin
  - Dissolve
  - Add sulphonating reagent
  - Controlled mole% sulphonation reaction
  - Clean polymer
  - Re-dissolve in alcohol
  - Solvent Cast



Moisture Membrane Material

- **Resulting membrane has greater dry tensile strength, glass transition temperature, and melt temperature**

  But….absorbs and transports water….

- **Membrane can be designed to absorb moisture from 20% to 200% of dry weight**

- **Membrane is inherently anti-bacterial and anti-fungal (polymeric acid)….also useful for human implantable medical devices**

Moisture Membrane Material

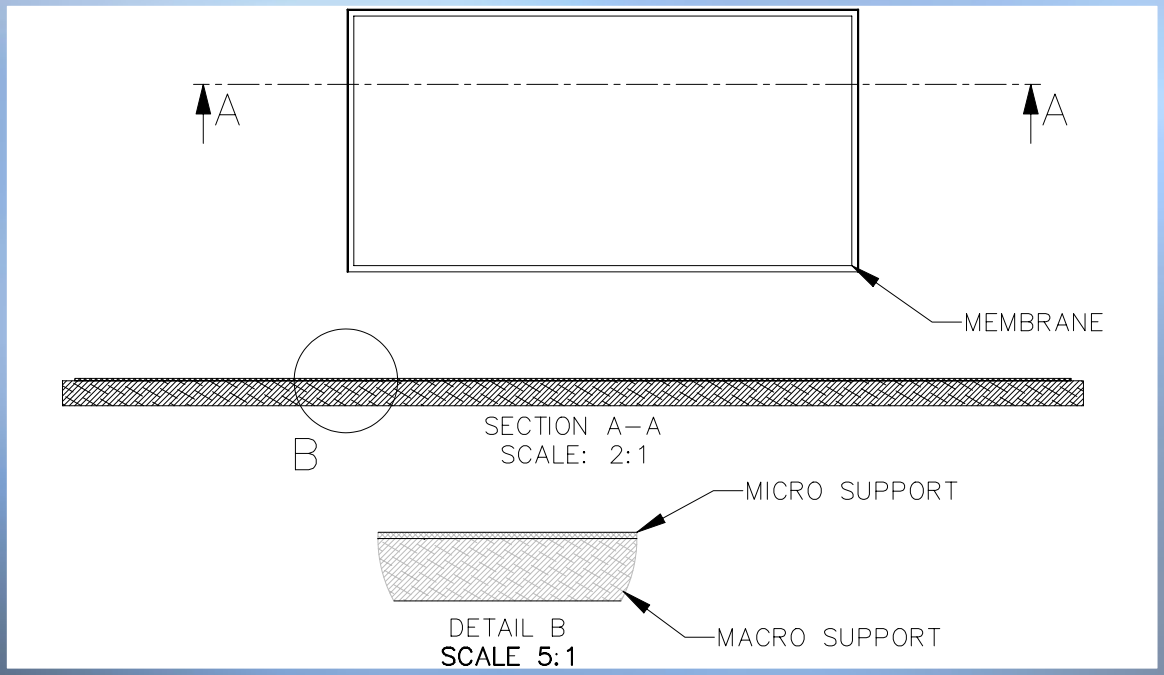
- Additional chemistry available through additives
  - Pre and post casting processes
  - Confer immunity to oxidative degradation
  - Greater wet mechanical strength
  - Additional biological growth inhibitors
  - Selective permeability
    - (reject certain alcohols)

Membrane Structure

- Membrane Thickness range .001” to .003”
- Most applications will use composite membranes
  - Micro-supports (in the membrane)
    - Non-woven
    - Micro-porous
  - Macro-supports (attached to the membrane)
    - Cloth
    - Plastic Netting
    - Macro-porous metals and ceramics

Membrane Structure

- **Cross-section of Composite Membrane**

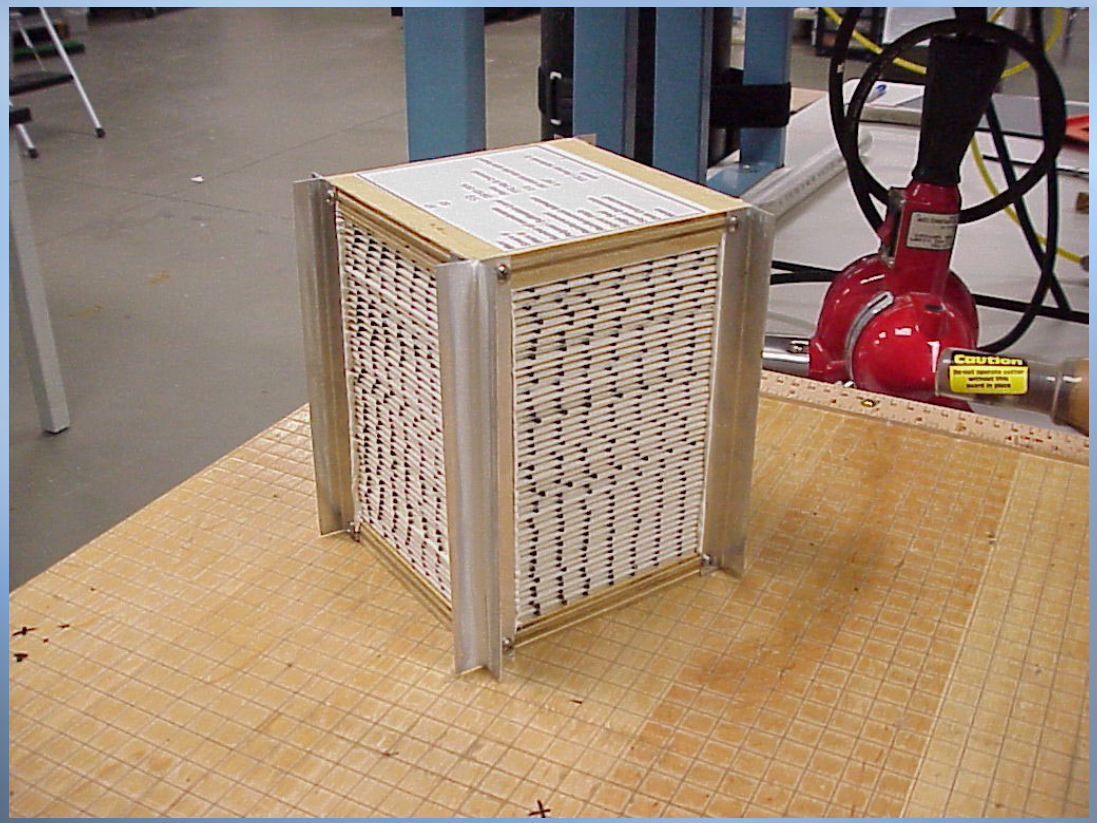


NREL Current Research Project

- Objectives
  - 400 CFM Core
  - Higher latent effectiveness 50% or greater
  - Reduced pressure drop
  - Reduced cost
  - Retain high sensible heat transfer

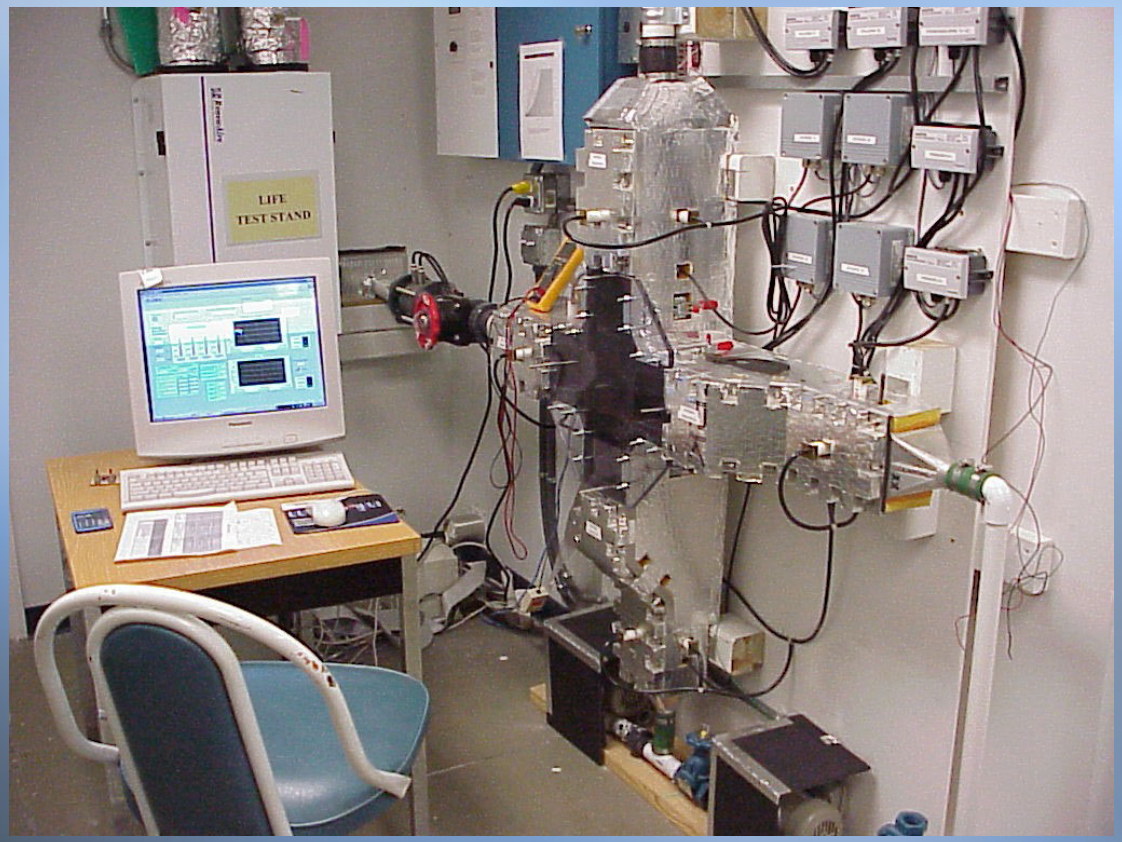
Moisture Membrane/Core Testing

- Created membrane Benchscale core(s) for testing



Moisture Membrane/Core Testing

- Created Bench Scale tester

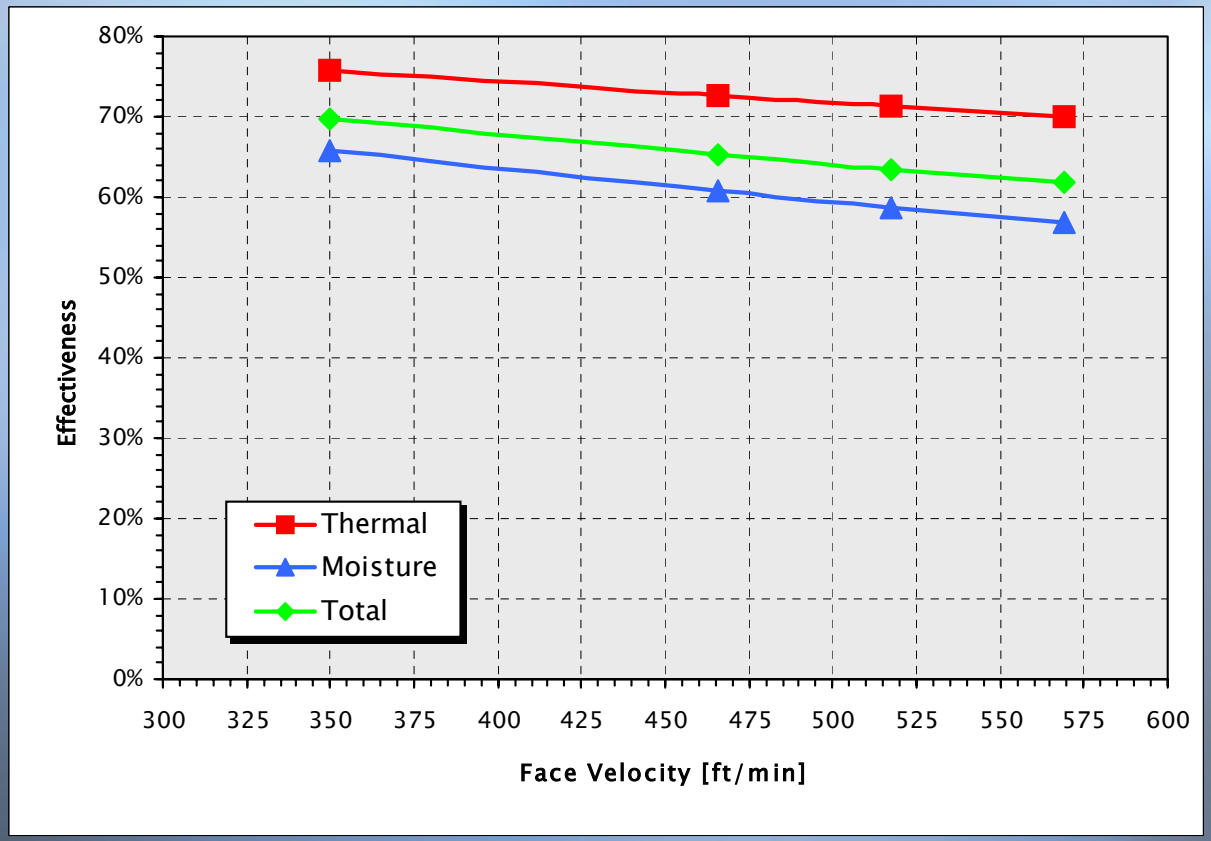


Moisture Membrane/Core Testing

- Benchscale Core and Tester were used to explore
  - Membrane chemistry
  - Membrane structures
  - Core construction
    - Assembly techniques
    - Assembly materials
  - Constructing and verifying computer models

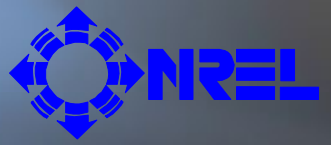
Moisture Membrane/Core Testing

Benchscale testing has confirmed that high efficiency is possible with certain membrane structures and core assembly architectures.



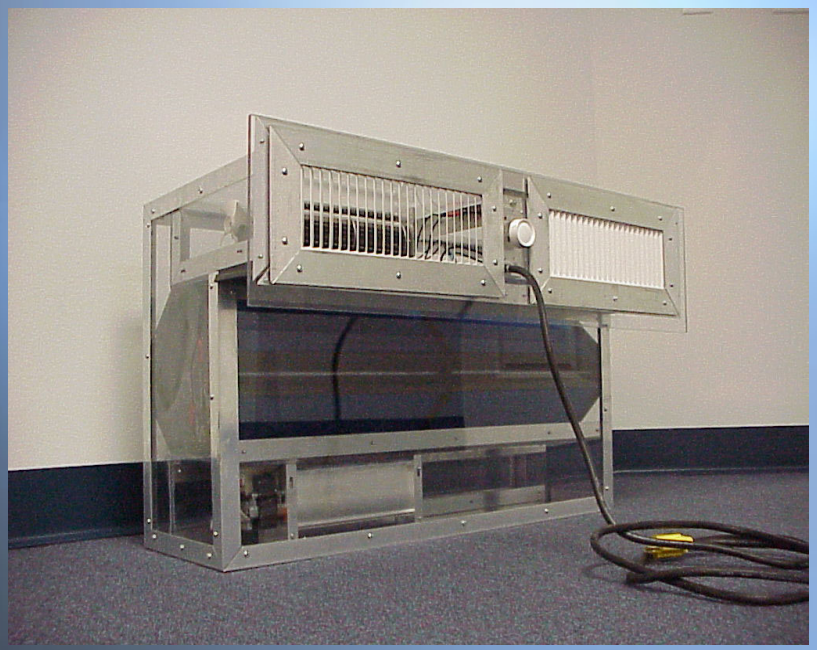
Moisture Membrane Applications

- ERV Cores are in the field for testing
  - There are three sizes being tested
    - Window 40-60 CFM
    - Single Residence 120-150 CFM
    - Commercial * 450 CFM
      - Will be installed shortly
      - Scaleable to 1000(s) of CFM with multiple cores



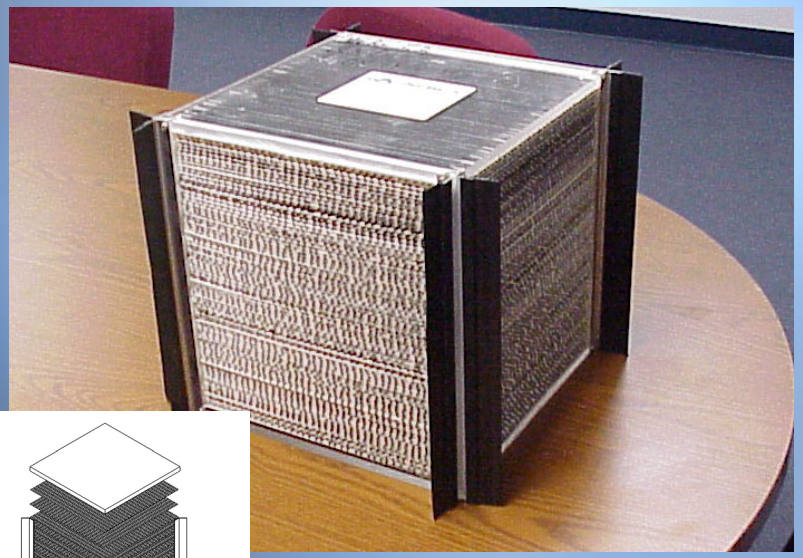
Moisture Membrane Applications

- **Window Size ERV – neutral air operation**



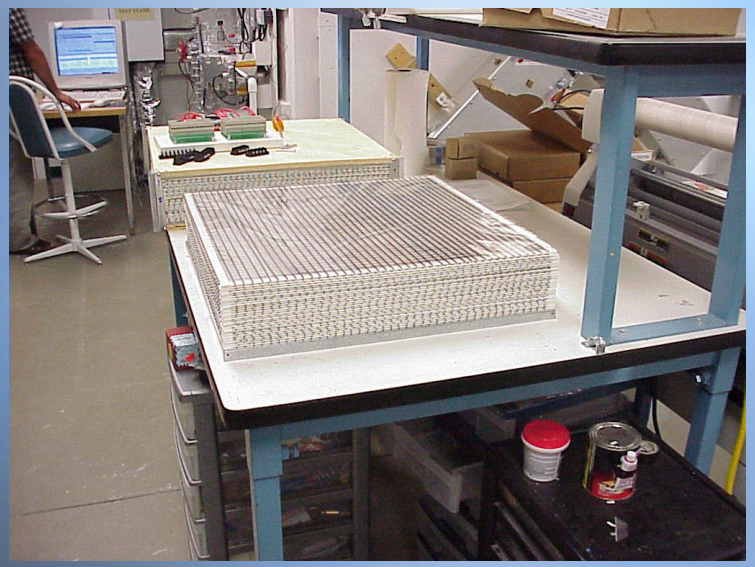
Moisture Applications

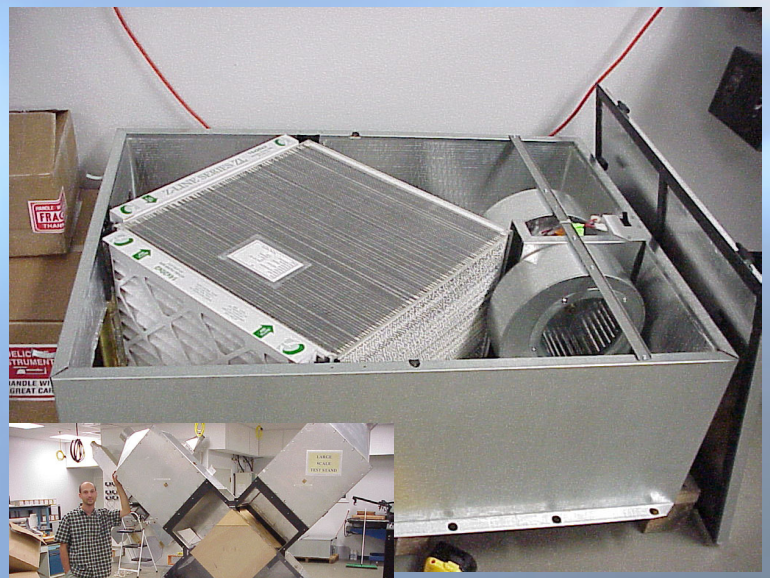
- **Residential**



Moisture Applications

- **Commercial ERV**





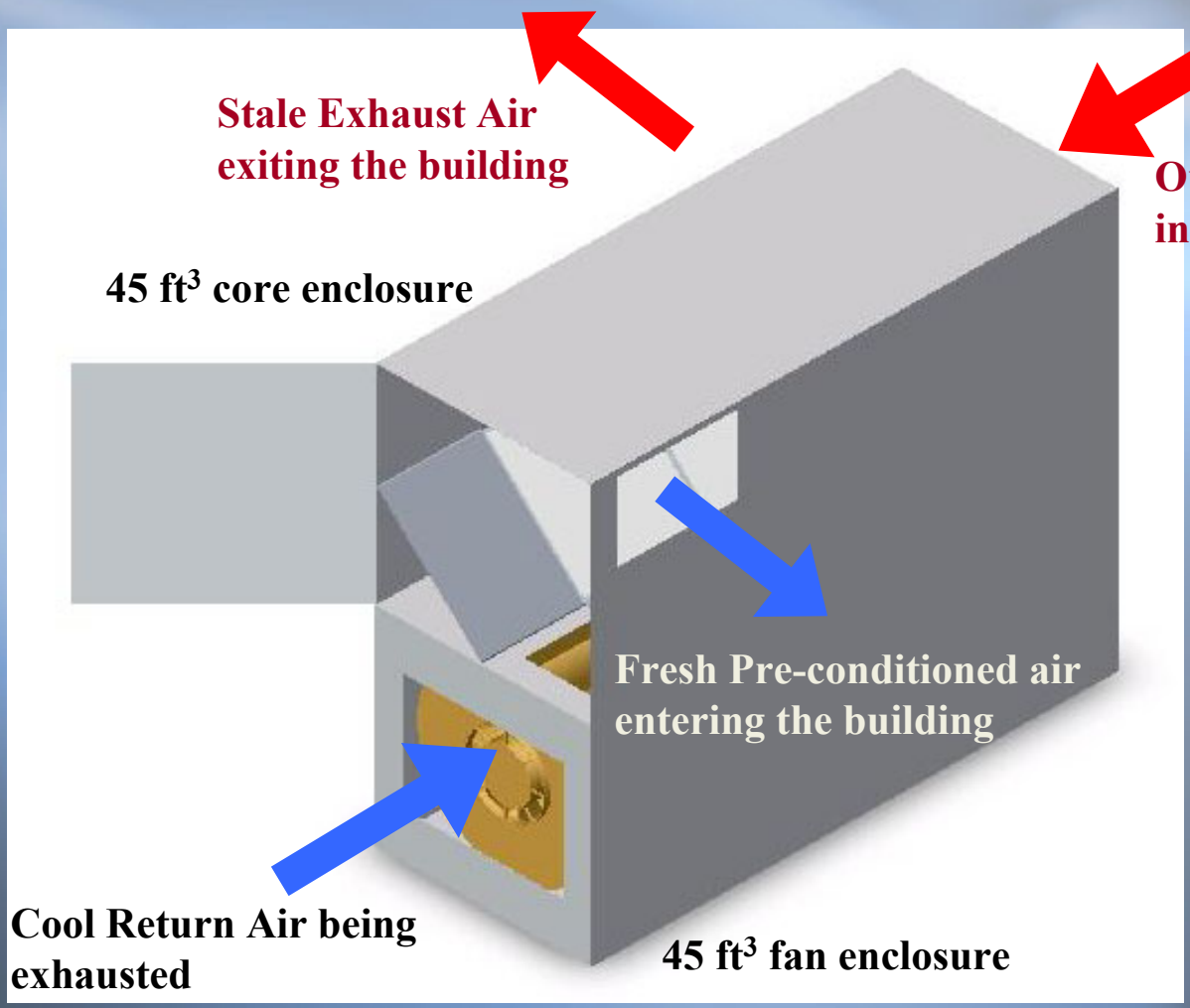
Moisture Applications

- Scale Factors Associated with large Membrane Energy Recovery Applications
  - 4000 CFM Wheel with enclosure

    Occupies 60 cu ft
  - Single 4000 CFM cross-flow core 4.5'x4.5'.x4.5' would occupy 91 cu ft – with enclosure >120 cu ft
  - But, other packing and flow arrangements will yield small form factors -- more research and testing is needed

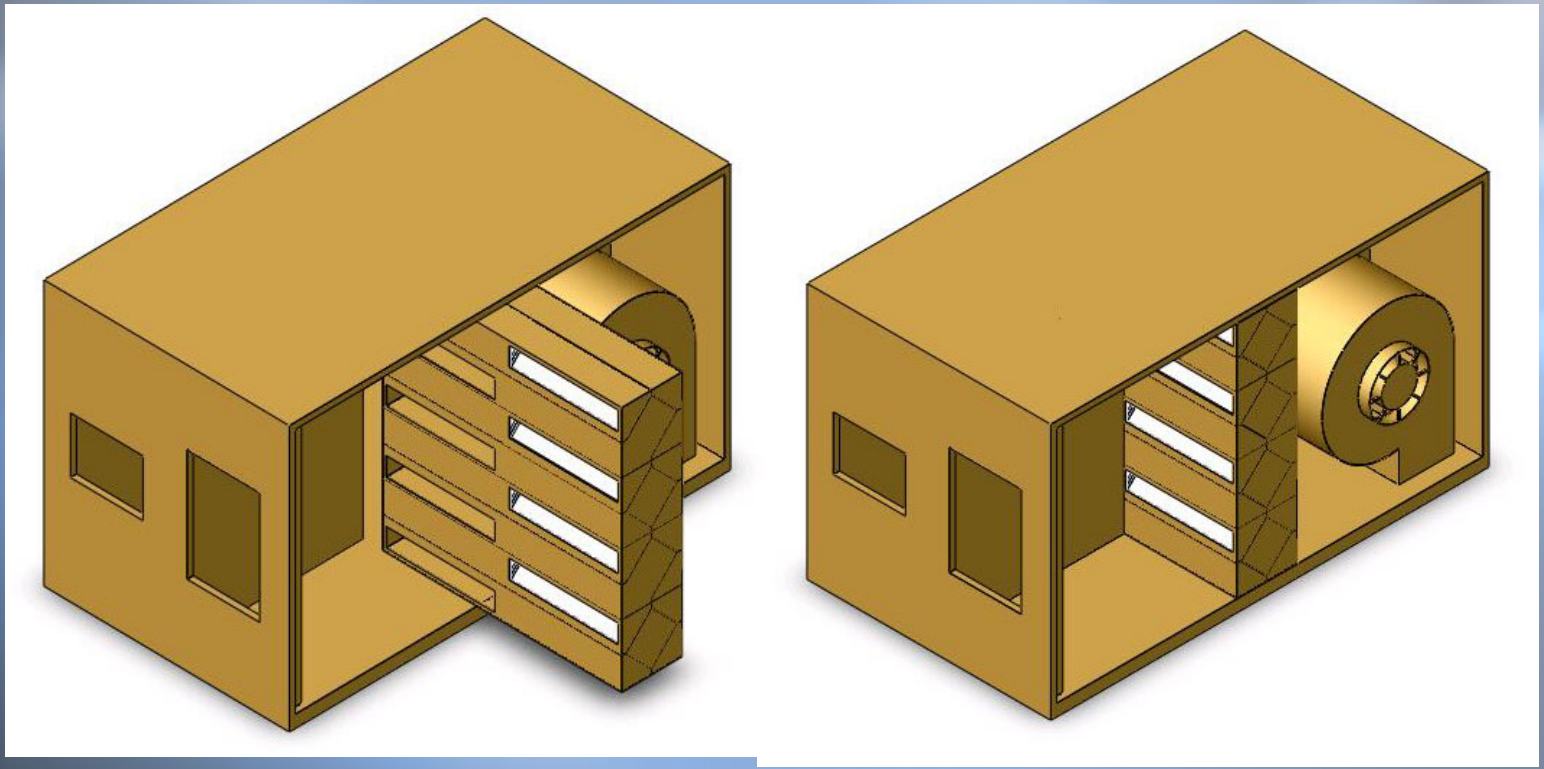
ERV Applications

4000 CFM Enclosure based on modular commercial cores



ERV Applications

Enclosure based on Modular Residential Core

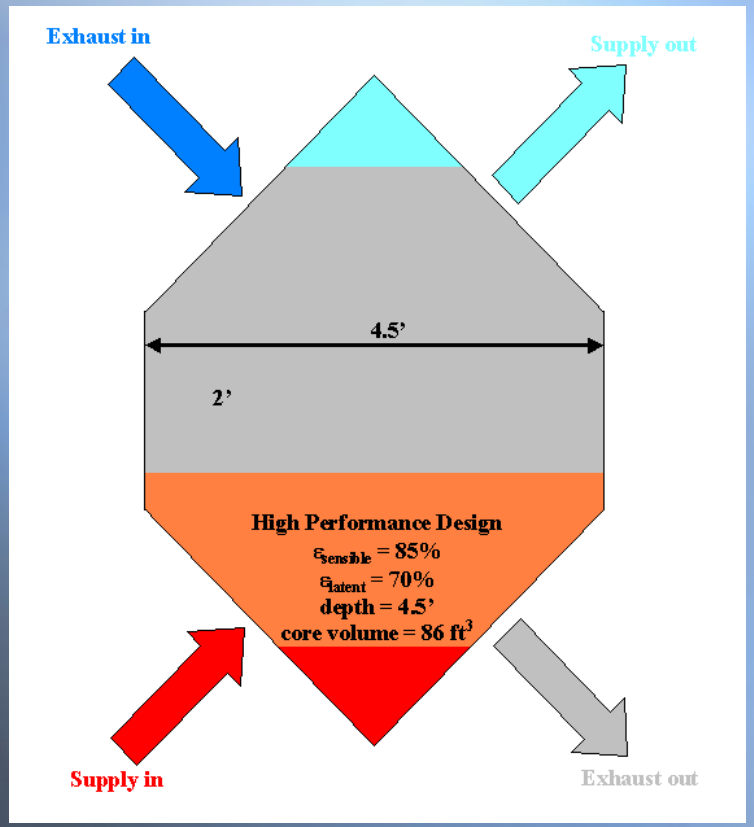


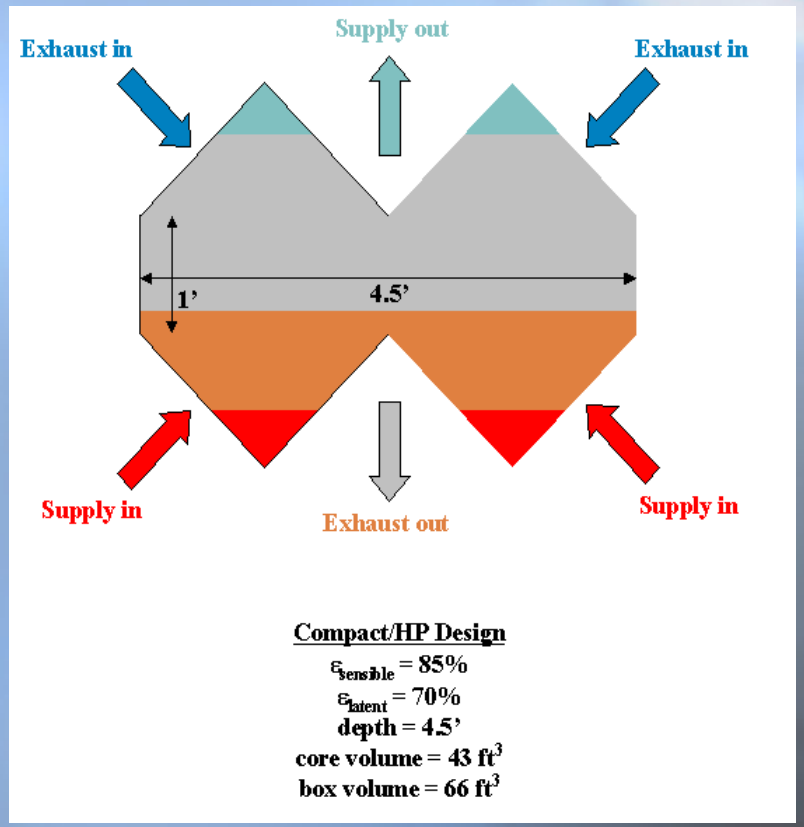
Replacement of enthalpy wheel with ERV cassette

Cassette has a volume of <9 ft^3

Future ERV Designs

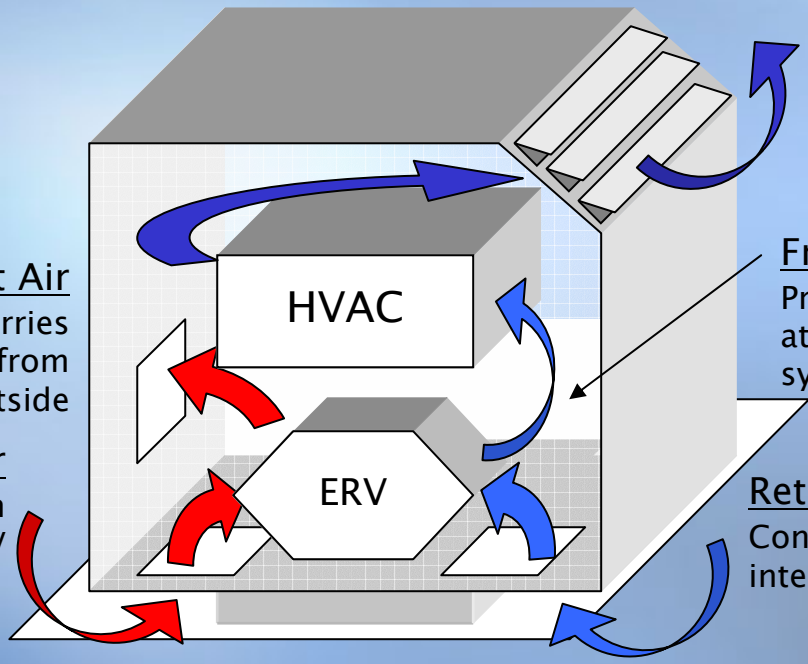
- Counterflow MERV Geometries - Joe Ryan (NREL)





Future ERV Applications

Counter-flow Core for Single Room Applications



Room Air Supply
Conditioned air delivered to the room by A/C system

Fresh Air
Preconditioned air at inlet of the HVAC system

Return Air
Conditioned air from interior space

Exhaust Air
Stale air carries energy removed from the fresh air outside

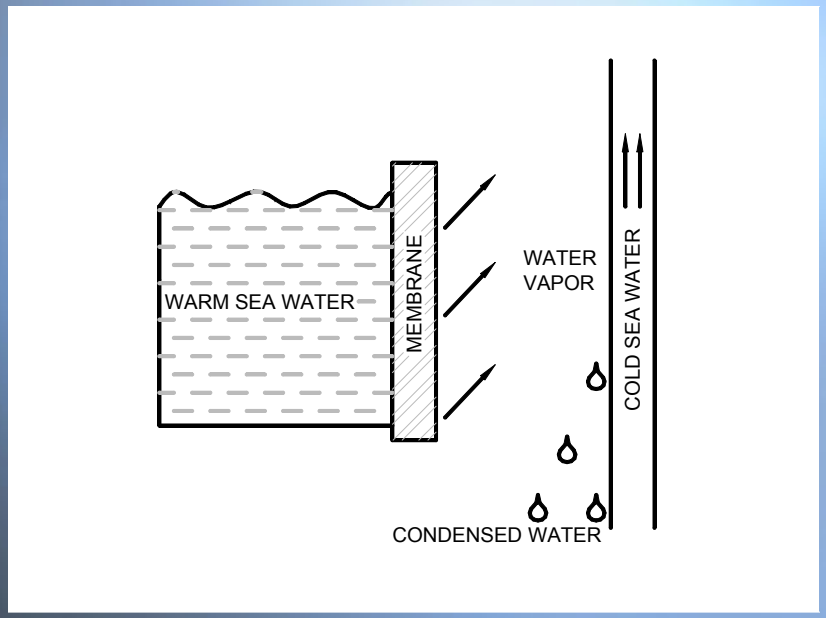
Outside Air
Warm, humid fresh air introduced to ERV

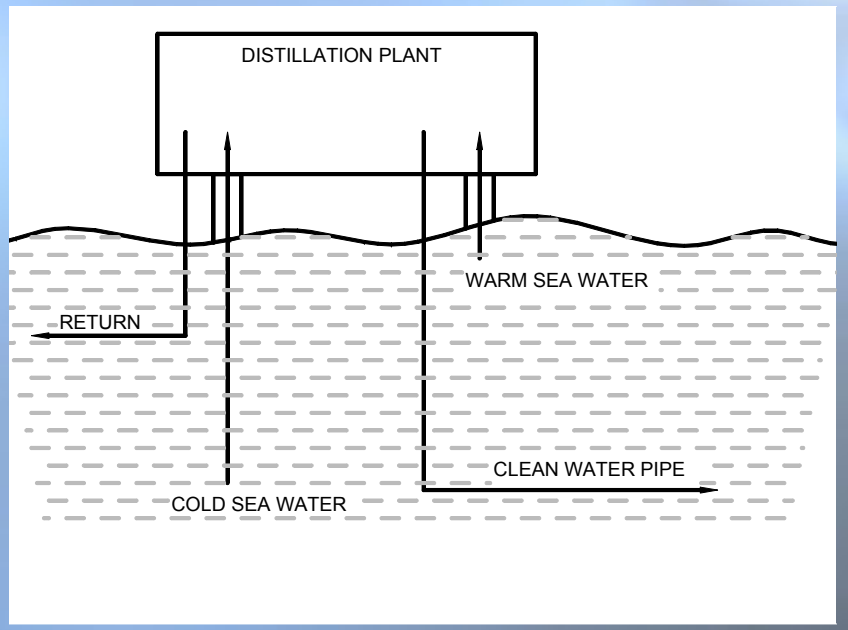
Future ERV Applications

- Distributed MERV for new construction
  - Eliminate MERV exchanger at compressor site
  - Air-conditioning is internal re-circulation only
  - Install fan driven MERV ventilators in rooms or building sections
  - MERV operation is slaved to building use

Other Moisture Applications

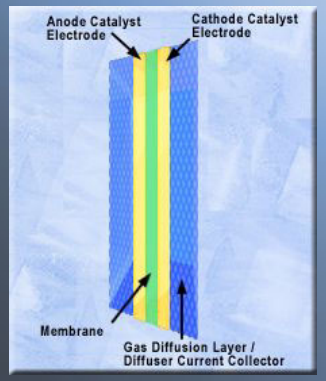
- **Distillation Membranes for Desalination of Seawater**

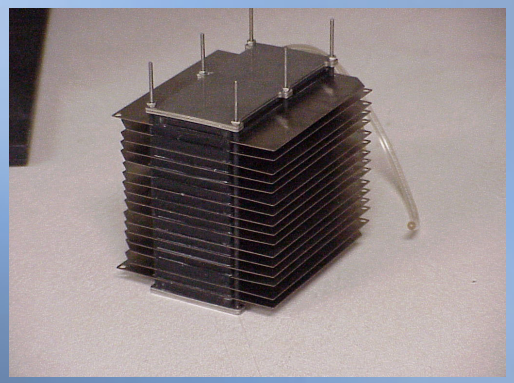


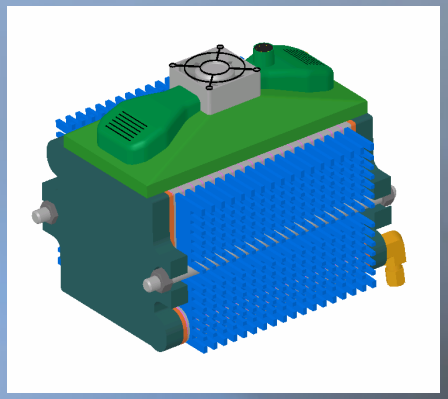


Other Membrane Applications

- Fuel Cell Membranes
  - Excellent conductivity/water characteristics
  - New anti-oxidant strategy will yield long lifetime
  - New catalytic structures under development
  - Part of a strategy for $10/sq ft MEA price







DER DISTRIBUTED ENERGY RESOURCES

NREL

Commercialization

- Scaling Polymer Production
  - Large Batches at “toll” houses
  - Continuous production for very large volumes
- MERV Core Assembly
  - Current techniques adequate for moderate volume
  - New techniques based on computer air-flow/exchange models and customer evaluations for high volume production

Summary

- MERV will have very high efficiencies (>70%) based on current membrane and core construction
- Scaling the production technology is our current challenge
- A number of configurations and strategies for employing the technology are possible
  - Potential to address all market segments
  - Individual windows units up to commercial building
- More research needed on core form factor for size reduction and efficacy